

# HEAT EXCHANGER

## CROSS REFERENCE TO REPLATED APPLICATION

This application claims benefit of priority under 35 U.S.C § 119 to  
5 Japanese Patent Application No.2002-348156, filed on November 29, 2002,  
the entire contents of which are incorporated by reference herein.

## BACKGROUND OF THE INVENTION

### 1. Field of the Invention

10 The present invention relates to a heat exchanger and, more  
specifically, to a heat exchanger including a downsized inlet manifold and a  
downsized outlet manifold.

### 2. Description of the Related Art

As a conventional heat exchanger, known is the heat exchanger  
15 disclosed in Published Japanese Translation of PCT International  
Application No. 2001 - 525051. In FIGs. 1 to 5, the lateral, longitudinal  
and height directions of a heat exchanger 50 are defined as X, Y and Z axes,  
respectively. The X, Y and Z axes are orthogonal to one another. As  
shown in FIG. 1, the heat exchanger 50 includes tubes 51, corrugated fins  
20 52, a pair of header pipes 53, an inlet manifold 54, an outlet manifold 55,  
and a pair of blocking caps 56. The plurality of tubes 51 are arranged  
along the X axis mutually in parallel and at even intervals. Each of the  
plurality of corrugated fins 52 is disposed between two adjacent tubes 51.  
The pair of header pipes 53 house both ends of the plurality of tubes 51.  
25 The inlet manifold 54 is fixed to one end of the header pipe 53 on a -X side.  
The outlet manifold 55 is fixed to one end of the header pipe 53 on a +X side.

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The pair of blocking caps 56 block the respective other ends of the pair of header pipes 53.

The heat exchanger 50 causes a first fluid flowing in from the inlet manifold 54 to circulate along a given passage formed of the header pipes 53 and the tubes 51. In the heat exchanger 50, heat exchange takes place efficiently between the first fluid passing inside the tubes 51 and a second fluid passing outside the tubes 51.

In the heat exchanger 50, as shown in FIGs. 2 and 3, four fluid circulation holes 57 are formed, in parallel, inside each header pipe 53 along a longitudinal direction of the header pipe 53, and a plurality of tube insertion holes 58 are formed along a lateral direction of the header pipe 53 in parallel. The fluid circulation holes 57 and the tube insertion holes 58 are orthogonal to one another. One ends of the tube insertion holes 58 penetrate through an outer side surface 53a of each header pipe 53 and are opened to the outside of each header pipe 53. Both end portions of the tubes 51 are inserted into the tube insertion holes 58 and are fixed to the header pipes 53 by brazing or the like.

As shown in FIG. 4, at an upper end portion of the header pipe 53 on the -X side, the fluid circulation holes 57 are opened to an inlet hole 54a of the inlet manifold 54. In order to connect the header pipe 53 on the -X side to the inlet manifold 54, a manifold side connection hole 54b having the same shape as the upper end portion of the header pipe 53 on the -X side is formed on a lower surface of the inlet manifold 54. The upper end portion of the header pipe 53 on the -X side is inserted into the manifold side connection hole 54b of the inlet manifold 54 and fixed to the inlet manifold 54 by brazing or the like. Moreover, the header pipes 53 are

fixed to the outlet manifold 55 and the blocking caps 56 in a similar manner.

When the heat exchanger 50 is manufactured as described above, in order to insert the upper end portion of the header pipe 53 on the -X side directly into the inlet manifold 54, the manifold side connection hole 54b having the same shape as the upper end portion of the header pipe 53 on the -X side is formed on the lower surface of the inlet manifold 54. Therefore, as shown in FIG. 5, in a cross section parallel to an X-Y plane, the area of the inlet manifold 54 is to be greater than the area of the upper end portion of the header pipe 53 on the -X side. Similarly, manifold side connection holes (not shown) having the same shapes as the end portions of the header pipes 53 are also formed on the outlet manifold 55 and the blocking caps 56. Accordingly, in the cross section parallel to the X-Y plane, the areas of the outlet manifold 55 and the blocking caps 56 each become greater than the areas of the respective end portions of the header pipes 53. Therefore, the inlet manifold 54, the outlet manifold 55, and the blocking caps 56 are each formed larger than the respective end portions of the header pipes 53, thereby incurring an increase in size of the heat exchanger 50 and difficulty in handling the heat exchanger 50.

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## SUMMARY OF THE INVENTION

An object of the present invention is to provide a heat exchanger in which an inlet manifold and an outlet manifold are configured in small sizes so as to downsize the entire heat exchanger.

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To attain the above object, the present invention provides a heat exchanger including a header pipe having a fluid circulation hole inside, an

inlet manifold having an inlet hole inside, an outlet manifold having an outlet hole inside, a first coupling member which has a first coupling hole inside and one end of which is connected to one end of the header pipe and the other end of which is connected to the inlet manifold, and a second coupling member which has a second coupling hole inside and one end of which is connected to the other end of the header pipe and the other end of which is connected to the outlet manifold. Herein, in the first coupling member, one end of the first coupling hole is opened to one end of the fluid circulation hole and the other end of the first coupling hole is opened to the inlet hole. Meanwhile, in the second coupling member, one end of the second coupling hole is opened to the other end of the fluid circulation hole and the other end of the second coupling hole is opened to the outlet hole.

According to the present invention, the header pipe is connected to the inlet manifold and the outlet manifold through the coupling members. Therefore, it is possible to freely form manifold side connection holes of the inlet manifold and the outlet manifold without dependence on the shapes of the end portions of the header pipe. Hence, it is possible to downsize the entire heat exchanger by configuring the inlet manifold and the outlet manifold in small sizes.

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#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic front view of a conventional heat exchanger.

FIG. 2 is a cross-sectional view taken along the C-C line in FIG. 1.

FIG. 3 is a front view of a header pipe in the conventional heat exchanger.

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FIG. 4 is an X-Z sectional view of a connection point between the

header pipe and an inlet manifold in the conventional heat exchanger.

FIG. 5 is an X-Y sectional view of the connection point between the header pipe and the inlet manifold in the conventional heat exchanger.

FIG. 6A is a plan view of a heat exchanger according to a first  
5 embodiment.

FIG. 6B is a front view of the heat exchanger.

FIG. 6C is a side view of the heat exchanger.

FIG. 7A is a sectional view of a connection point between a header pipe and an inlet manifold in the first embodiment.

10 FIG. 7B is an exploded perspective view of the connection point between the header pipe and the inlet manifold.

FIG. 8A is a sectional view of a connection point between the header pipe and an outlet manifold in the first embodiment.

FIG. 8B is an exploded perspective view of the connection point  
15 between the header pipe and the outlet manifold.

FIG. 9 is an exploded perspective view of a connection point between a header pipe and an inlet manifold (or an outlet manifold) in a second embodiment.

FIG. 10 is an exploded perspective view of a connection point  
20 between a header pipe and an inlet manifold (or an outlet manifold) in a third embodiment.

FIG. 11 is an exploded perspective view of a connection point between a header pipe and an inlet manifold (or an outlet manifold) in a fourth embodiment.

25 FIG. 12 is an exploded perspective view of a connection point between a header pipe and an inlet manifold (or an outlet manifold) in the

other embodiment.

FIG. 13 is an exploded perspective view of a connection point between the header pipe and the inlet manifold (or an outlet manifold) in the other embodiment.

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## DESCRIPTION OF THE PREFERRED EMBODIMENTS

First to fourth embodiments of the present invention will now be described with reference to FIGs. 6A to 11. The lateral, longitudinal and height directions of a heat exchanger 1, 31, 32, or 33 are defined as X, Y and Z axes, respectively. The X, Y and Z axes are orthogonal to one another.

### (First Embodiment)

As shown in FIGs. 6A to 6C, a heat exchanger 1 includes tubes 2, corrugated fins 3, an upper header pipe 4a, a lower header pipe 4b, coupling members 5a, 5b, 5c, and 5d, an inlet manifold 6, an outlet manifold 7, and blocking caps 8. The plurality of tubes 2 are arranged along the Z axis mutually in parallel and at even intervals. The plurality of corrugated fins 3 are each disposed between two adjacent tubes 2 along the X axis (which are only partially illustrated in FIG. 6B). The upper header pipe 4a houses one ends (+Z side) of the tubes 2. The lower header pipe 4b houses the other ends (-Z side) of the tubes 2. The inlet manifold 6 is fixed to one end (+X side) of the upper header pipe 4a through the coupling members 5a, 5b, 5c, and 5d. The outlet manifold 7 is fixed to the other end (-X side) of the upper header pipe 4a through other coupling members 5a, 5b, 5c, and 5d. The blocking caps 8 separately block both ends of the lower header pipe 4b.

Each tube 2 is made of an aluminum material (such as A1050) and formed into a flat plate shape. A plurality of circulation holes (not shown) with openings at both ends are formed inside each tube 2. The plurality of circulation holes are arranged along the Z axis mutually in parallel. The one ends (+Z side) of the tubes 2 are inserted into upper tube insertion  
5 holes (not shown) of the upper header pipe 4a and fixed to the upper header pipe 4a by brazing. The other ends (-Z side) of the tubes 2 are inserted into lower tube insertion holes (not shown) of the lower header pipe 4b and fixed to the lower header pipe 4b by brazing.

10 Each corrugated fin 3 is made of an aluminum material (such as A3003) and formed into a corrugated shape. Each corrugated film 3 is fixed between two adjacent tubes 2 by brazing.

The upper header pipe 4a is made of an aluminum material (such as A3003). Fluid circulation holes 10a, 10b, 10c, and 10d, each of which  
15 has openings on both ends, are formed inside the upper header pipe 4a. The fluid circulation holes 10a, 10b, 10c, and 10d are arranged along the X axis mutually in parallel. A partition wall 11 is provided at a central part inside the upper header pipe 4a. The partition wall 11 partitions each of the fluid circulation holes 10a, 10b, 10c, and 10d into two regions (a +X side  
20 portion and a -X side portion). The upper tube insertion holes are formed on a lower surface of the upper header pipe 4a at even intervals along the X axis and the Y axis. One end of each upper tube insertion hole is opened to one of the fluid circulation holes 10a, 10b, 10c, and 10d.

Four fluid circulation holes (not shown), each having openings on  
25 both ends, are formed inside the lower header pipe 4b. The fluid circulation holes are arranged along the X axis mutually in parallel. The

lower tube insertion holes are formed on an upper surface of the lower header pipe 4b at even intervals along the X axis and the Y axis. One end of each lower tube insertion hole is opened to one of the four fluid circulation holes.

5           As shown in FIGs. 7A and 7B, the inlet manifold 6 is formed into a cylindrical shape and includes an inlet hole 12 inside. Manifold side connection holes 13a, 13b, 13c, and 13d are formed along the X axis on a side surface of the inlet manifold 6. The manifold side connection holes 13a, 13b, 13c, and 13d communicate with the inlet hole 12. Pipe side  
10 connection holes 17a, 17b, 17c, and 17d are formed along the X axis on the one end (+X side) of the upper header pipe 4a. The fluid circulation holes 10a, 10b, 10c and 10d are opened at central parts of one ends (-X side) of the pipe side connection holes 17a, 17b, 17c and 17d, respectively.

          The coupling members 5a, 5b, 5c, and 5d disposed on the one end  
15 (+X side) of the upper header pipe 4a are formed into cylindrical shapes of the same size. Diameters of the manifold side connection holes 13a, 13b, 13c, and 13d are the same as diameters of the coupling members 5a, 5b, 5c, and 5d, respectively. Diameters of the pipe side connection holes 17a, 17b, 17c, and 17d are the same as the diameters of the coupling members 5a, 5b,  
20 5c, and 5d, respectively. Coupling holes 16a, 16b, 16c, and 16d are formed inside the coupling members 5a, 5b, 5c, and 5d, respectively. One ends (-X side) of the coupling members 5a, 5b, 5c and 5d are inserted into the pipe side connection holes 17a, 17b, 17c and 17d, respectively. The other ends (+X side) of the coupling members 5a, 5b, 5c and 5d are inserted into the  
25 manifold side connection holes 13a, 13b, 13c and 13d, respectively. The upper header pipe 4a is connected to the inlet manifold 6 through the

coupling members 5a, 5b, 5c, and 5d. The coupling members 5a, 5b, 5c, and 5d are fixed to the upper header pipe 4a and the inlet manifold 6 by brazing. The fluid circulation holes 10a, 10b, 10c, and 10d communicate with the inlet hole 12 of the inlet manifold 6 through the coupling holes 16a, 16b, 16c, and 16d. Diameters of the coupling holes 16a, 16b, 16c, and 16d are gradually reduced toward the +Y direction, in other words, starting from an inlet portion 6a of the inlet manifold 6.

As shown in FIGs. 8A and 8B, the outlet manifold 7 is formed into a cylindrical shape and includes an outlet hole 14 inside thereof. Manifold side connection holes 15a, 15b, 15c, and 15d are formed along the X axis on a side surface of the outlet manifold 7. The manifold side connection holes 15a, 15b, 15c, and 15d communicate with the outlet hole 14. Pipe side connection holes 18a, 18b, 18c, and 18d are formed along the X axis on the other end (-X side) of the upper header pipe 4a. The fluid circulation holes 10a, 10b, 10c and 10d are opened at central parts of one ends (+X side) of the pipe side connection holes 18a, 18b, 18c and 18d.

The coupling members 5a, 5b, 5c, and 5d disposed on the other end (-X side) of the upper header pipe 4a are formed into cylindrical shapes of the same size. Diameters of the manifold side connection holes 15a, 15b, 15c, and 15d are the same as the diameters of the coupling members 5a, 5b, 5c, and 5d, respectively. Diameters of the pipe side connection holes 18a, 18b, 18c, and 18d are the same as the diameters of the coupling members 5a, 5b, 5c, and 5d, respectively. Coupling holes 16a, 16b, 16c, and 16d are formed inside the coupling members 5a, 5b, 5c, and 5d, respectively. One ends (+X side) of the coupling members 5a, 5b, 5c and 5d are inserted into the pipe side connection holes 18a, 18b, 18c and 18d, respectively. The

other ends (-X side) of the coupling members 5a, 5b, 5c and 5d are inserted into the manifold side connection holes 15a, 15b, 15c and 15d, respectively. The upper header pipe 4a is connected to the outlet manifold 7 through the coupling members 5a, 5b, 5c, and 5d. The coupling members 5a, 5b, 5c, and 5d are fixed to the upper header pipe 4a and the outlet manifold 7 by brazing. The fluid circulation holes 10a, 10b, 10c, and 10d communicate with the outlet hole 14 of the outlet manifold 7 through the coupling holes 16a, 16b, 16c, and 16d. The diameters of the coupling holes 16a, 16b, 16c, and 16d are gradually reduced toward the +Y direction, in other words, starting from an outlet portion 7a of the outlet manifold 7.

A first fluid flowing inside the heat exchanger 1 travels from the inlet manifold 6 to the outlet manifold 7 via the following pathway: the coupling members 5a, 5b, 5c, and 5d; the +X side portion of the upper header pipe 4a; the tubes 2 located below the +X side portion of the upper header pipe 4a; the lower header pipe 4b; the tubes 2 located below the -X side portion of the upper header pipe 4a; the -X side portion of the upper header pipe 4a; and the other coupling members 5a, 5b, 5c, and 5d. In the heat exchanger 1, heat exchange mainly takes place between the first fluid passing inside the tubes 2 and a second fluid passing outside the tubes 2 efficiently.

The heat exchanger 1 of the above-described configuration has the following characteristics.

Since the upper header pipe 4a is connected to the inlet manifold 6 and the outlet manifold 7 through the coupling members 5a, 5b, 5c, and 5d, it is not necessary to form the manifold side connection holes to be formed on the inlet manifold 6 and the outlet manifold 7 in the same shapes as the

end portions of the upper header pipe 4a. Therefore, in a cross-section parallel to a Y-Z plane, the area of the inlet manifold 6 or the output manifold 7 becomes the same as or smaller than the area of the end portion of the upper header pipe 4a. As a result, it is possible to downsize the inlet manifold 6 and the output manifold 7, and thereby to downsize the heat exchanger 1.

Moreover, it is possible to sufficiently reduce the sizes of the manifold side connection holes of the inlet manifold 6 and the outlet manifold 7 as compared to the sizes of conventional manifold connection holes, which is advantageous in terms of pressure resistance. It is also possible to sufficiently reduce the thicknesses of the inlet manifold 6 and the outlet manifold 7 as compared to the thicknesses of a conventional inlet manifold and a conventional outlet manifold. Thus, weight reduction of the heat exchanger 1 is achieved.

It is possible to adjust flow rates of the fluid flowing into the fluid circulation holes 10a, 10b, 10c, and 10d of the header pipe 4a by changing the diameters of the coupling holes 16a, 16b, 16c, and 16d of the coupling members 5a, 5b, 5c, and 5d. Accordingly, it is possible to prevent a drift (a flow with unbalanced flow rate distribution) of the fluid inside the header pipe 4a.

#### (Second Embodiment)

In comparison with the heat exchanger 1 of the first embodiment, a heat exchanger 31 is different in configurations of the coupling members 5a, 5b, 5c, and 5d, of the pipe side connection holes at the end portion of the upper header pipe 4a, of the manifold side connection holes of the inlet

manifold 6, and of the manifold side connection holes of the outlet manifold 7. To be more specific, in the heat exchanger 1, the coupling members 5a, 5b, 5c, and 5d are severally inserted into the pipe side connection holes and into the manifold side connection holes to connect the upper header pipe 4a to the inlet manifold 6 (or the outlet manifold 7). In the heat exchanger 31, a single coupling member 21 is inserted into a pipe side connection hole and a manifold side connection hole to connect the upper header pipe 4a to the inlet manifold 6 (or the outlet manifold 7). The other members are configured as similar to those in the heat exchanger 1 of the first embodiment, and therefore, description thereof will be omitted.

As shown in FIG. 9, a pipe side connection hole 20 of an elliptical shape is formed on each end portion of the upper header pipe 4a. The fluid circulation holes 10a, 10b, 10c, and 10d are opened at one end of each pipe side connection hole 20. A manifold side connection hole (not shown) of the same shape as the pipe side connection holes 20 is formed on a side surface of each of the inlet manifold 6 and the outlet manifold 7.

The coupling members 21 are elliptic cylinders having the same cross-sectional shape as the shape of the pipe side connection holes 20 and the manifold side connection holes. One end of each coupling member 21 is inserted into each pipe side connection hole 20 of the upper header pipe 4a. The other end of each coupling member 21 is inserted into the manifold side connection hole of the inlet manifold 6 (or the outlet manifold 7). Both the ends of each coupling member 21 are fixed to the upper header pipe 4a and the inlet manifold 6 (or the outlet manifold 7) by brazing. Coupling holes 22a, 22b, 22c, and 22d are formed inside each coupling member 21. One ends of the coupling holes 22a, 22b, 22c and 22d

communicate with the fluid circulation holes 10a, 10b, 10c and 10d, respectively, and the other ends thereof communicate with the inlet hole 12 of the inlet manifold 6 (or the outlet hole 14 of the outlet manifold 7). Diameters of the coupling holes 22a, 22b, 22c, and 22d are gradually  
5 reduced starting from the inlet portion 6a of the inlet manifold 6 (or the outlet portion 7a of the outlet manifold 7).

The heat exchanger 31 thus configured has the following characteristics.

Since the upper header pipes 4a is connected to the inlet manifold 6  
10 and the outlet manifold 7 through the coupling members 21, it is not necessary to form the manifold side connection holes to be formed on the inlet manifold 6 and the outlet manifold 7 in the same shapes as the end portions of the upper header pipe 4a. Therefore, it is possible to downsize the inlet manifold 6 and the output manifold 7, and thereby to downsize the  
15 heat exchanger 31.

It is possible to sufficiently reduce the sizes of the manifold side connection holes of the inlet manifold 6 and of the outlet manifold 7 as compared to the sizes of conventional manifold connection holes, which is advantageous in terms of pressure resistance. It is also possible to  
20 sufficiently reduce the thicknesses of the inlet manifold 6 and the outlet manifold 7 as compared to the thicknesses of conventional inlet manifold and outlet manifold. Thus, weight reduction of the heat exchanger 31 is achieved.

It is possible to adjust flow rates of the fluid flowing into the fluid  
25 circulation holes 10a, 10b, 10c, and 10d of the upper header pipe 4a by changing the diameters of the coupling holes 22a, 22b, 22c, and 22d of the

coupling members 21. Thus, it is possible to prevent a drift (a flow with unbalanced flow rate distribution) of the fluid inside the upper header pipe 4a.

5 (Third Embodiment)

As shown in FIG. 10, in a heat exchanger 32, all the diameters of the coupling holes 16a, 16b, 16c, and 16d of the coupling members 5a, 5b, 5c, and 5d, respectively, are formed to the same size. The other members are configured as similar to those in the heat exchanger 1 of the first  
10 embodiment, and therefore, description thereof will be omitted. The heat exchanger 32 is applied to a case where it is not necessary to adjust a drift of the fluid inside the upper header pipe 4a.

The heat exchanger 32 thus configured has the following characteristics. It is possible to reduce manufacturing costs because all  
15 the coupling members 5a, 5b, 5c and 5d have the same structure. Moreover, it is not necessary to consider a fitting order when fitting the coupling members 5a, 5b, 5c, and 5d to the upper header pipe 4a and the inlet manifold 6 (or the outlet manifold 7). Accordingly, it is possible to shorten manufacturing time.

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(Fourth Embodiment)

As shown in FIG. 11, in a heat exchanger 33, all the diameters of the coupling holes 22a, 22b, 22c, and 22d of the coupling members 21 are formed in the same size. The other members are configured as similar to  
25 those in the heat exchanger 31 of the second embodiment, and therefore, description thereof will be omitted. The heat exchanger 33 is applied to a

case where it is not necessary to adjust a drift of the fluid inside the upper header pipe 4a.

The heat exchanger 33 thus configured has the following characteristics. It is possible to reduce manufacturing costs because all  
5 the coupling holes 22a, 22b, 22c and 22d have the same structure. Moreover, it is not necessary to consider a fitting order when fitting the coupling member 21 to the upper header pipe 4a and the inlet manifold 6 (or the outlet manifold 7). Accordingly, it is possible to shorten manufacturing time.

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#### (Other Embodiments)

Various modifications can be made in the heat exchanger of the present invention without limitations to the first to fourth embodiments.

For example, as shown in FIG. 12, in order to connect the upper  
15 header pipe 4a to the inlet manifold 6 (or the outlet manifold 7), male threads 23a, 23b, 23c and 23d which are respectively formed on outer surfaces of one end of the coupling members 5a, 5b, 5c and 5d, may be screwed into female threads 25a, 25b, 25c and 25d which are respectively formed on inner surfaces of the pipe side connection holes 17a, 17b, 17c and  
20 17d (or the pipe side connection holes 18a, 18b, 18c and 18d). Also, as shown in FIG. 13, in order to connect the upper header pipe 4a to the inlet manifold 6 (or the outlet manifold 7), male threads 27a, 27b, 27c and 27d which are respectively formed on outer surfaces of the other end of the coupling member 5a, 5b, 5c and 5d, may be screwed into female threads  
25 (not shown) which are respectively formed on inner surfaces of the manifold side connection holes (not shown). Further, the first to fourth

embodiments show the header pipe of a multiple-hole type, which includes the fluid circulation holes 10a, 10b, 10c, and 10d inside each of the upper header pipe 4a and the lower header pipe 4b. However, the present invention is not limited to this, and may employ a header pipe of a  
5 single-hole type, which includes a single fluid circulation hole inside each of the upper header pipe 4a and the lower header pipe 4b.

In the first to fourth embodiments, the inlet manifold 6 and the outlet manifold 7 are connected to both the ends of the upper header pipe 4a. However, the present invention is not limited to this, and positions  
10 where the inlet manifold 6 and the outlet manifold 7 are disposed may be any end of the upper header pipe 4a and the lower header pipe 4b.